DOCUMENT RESUME

ED 381 913 EC 303 859

AUTHOR	Fitzpatrick, Vicki, Ed.
TITLE	Machines That Make Books Talk.
INSTITUTION	Library of Congress, Washington, D.C. National Library Service for the Blind and Physically Handicapped.
PUB DATE	94
NOTE	21p.; Photographs may not reproduce well.
PUB TYPE	Reports - Descriptive (141) -- Collected Works - Serials (022)
JOURNAL CIT	Projects & Experiments; Fall 1994
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Audiotape Recordings; *Blindness; History; Library Networks; *Physical Disabilities; Research Projects; *Talking Books; *Technological Advancement
IDENTIFIERS	*National Library Service for the Blind

ABSTRACT

This paper describes playback equipment provided by the National Library Service for the Blind and Physically Handicapped's Talking Books program. The history of these machines is reviewed from 1933 to the present and includes activities during World War II, the introduction of flexible discs and cassettes, descriptions of a variety of machines (with photographs), and accessories. Opinions of users are summarized. The machine production process is also described from original conceptualization through determination of specifications, bid solicitation, building and testing of prototype and samples, ongoing manufacture of the product, and troubleshooting. Discussed in some detail is the contracting process for the manufacture of the machines and the inventory and maintenance processes implemented through machine-lending agencies around the country. One section looks at international cooperation in the exploration and standardization of future talking-book technology. Noted are current research efforts of the National Library Service which focus on the development of digital original mastering. Assumptions and requirements of a possible new talking-book system are listed. Some sections provide references. (DB)

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ED 381 913

Projects & Experiments

Fall 1994

National Library Service for the Blind and Physically Handicapped

The Library of Congress

Machines that make books talk

Projects & Experiments **is published on an occasional basis to summarize and provide in-depth information on technical developments and long-range projects of the National Library Service for the Blind and Physically Handicapped (NLS), Library of Congress.**

For more than sixty years, blind and physically handicapped Americans have had access to recreational reading material through the NLS program that gave rise to the term "talking books." For many people unable to see the printed word or handle printed books, the advent of recorded reading materials and the equipment on which to play them was the key to the intellectual freedom they now enjoy. Braille continues to be the basic medium of literacy for blind individuals—but almost all visually handicapped readers, including those proficient in braille, get information and reading pleasure from talking books.

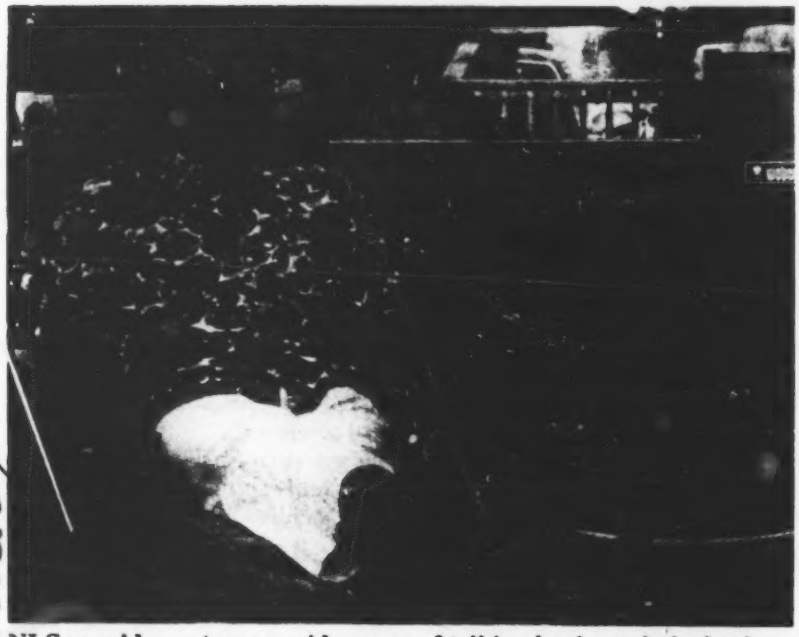
Evolution of technology has clearly been the guiding force characterizing the development of the talking-book program—from the original thirty-pound phonographs playing brittle, shellac records that held only fifteen minutes of audio material per side to today's lightweight, portable machines playing pocket-sized tape cassettes that each hold up to six hours of material. A profusion of machines has come and gone over the years, with ever-increasing acceptance among readers, until the realization of the current models that are, by all accounts, truly "user-friendly."

Along with talking-book machines, NLS developments include a variety of accessories to meet a wide range of needs and to assist with specific disabilities. Headphones for private listening, pillow speakers and remote control units for less mobile individuals, extension levers for those with limited hand strength, and solar-powered battery chargers for people living in remote locations are now among the devices available to help meet diverse user needs.

Other refinements—such as voice-indexing, which, through a sophisticated process of placing spoken index terms in precise locations to provide audible voice cues when the cassette is fast-forwarded—have extended the usability and practicality of recorded material for reference and other purposes and have tremendously enhanced the usefulness of such items as cookbooks in recorded form.

Always at the center of this evolution has been the talking-book user—an individual who might be a child or an adult, might be a laborer or a professional, might be retired or doing supplemental reading for school. With patrons of every age group, widely diverse interests, and differing capabilities, NLS is challenged to provide equipment that can satisfy most, if not all, individuals. This challenge is confronted daily and will no doubt continue to determine the course of future evolution.

—Judith Dixon



NLS provides patrons a wide range of talking books and playback equipment, including just the right book for relaxed summer reading on the deck.

EC 303859

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The Program
The National Library Service for the Blind and Physically Handicapped of the Library of Congress publishes books and magazines in braille and in recorded form on discs and cassettes for readers who cannot hold, handle, or see well enough to read conventional print because of a temporary or permanent visual or physical handicap.

Through a national network of state and local libraries, the materials are loaned free to eligible readers in the United States and to U.S. citizens living abroad. Materials are sent to readers and returned by postage-free mail.

Books and Magazines
Readers may borrow all types of popular-interest books including bestsellers, classics, mysteries, westerns, poetry, history, biographies, religious literature, children's books, and foreign-language materials. Readers may also subscribe to more than seventy popular magazines in braille and recorded formats.

Special Equipment
Special equipment needed to play the discs and cassettes, which are recorded at slower than conventional speeds, is loaned indefinitely to readers. An amplifier with headphone is available for blind and physically handicapped readers who are also certified as hearing impaired. Other devices are provided to aid readers with mobility impairments in using playback machines.

Eligibility
You are eligible for the Library of Congress program if:

- You are legally blind—your vision in the better eye is 20/200 or less with correcting glasses, or your widest diameter of visual field is no greater than 20 degrees;
- You cannot see well enough or focus long enough to read standard print, although you wear glasses to correct your vision;
- You are unable to handle print books or turn pages because of a physical handicap;
- Or, you are certified by a medical doctor as having a reading disability, due to an organic dysfunction, which is of sufficient severity to prevent reading in a normal manner.

How to Apply
You may request an application by writing NLS or calling toll-free 1-800-424-9100, and your name will be referred to your cooperating library.

Projects & Experiments is published occasionally by:
National Library Service for the
Blind and Physically Handicapped
Library of Congress
Washington, DC 20542
All correspondence should be addressed to the attention of Publications and Media Section. To change address or cancel subscription, please enclose mailing label.

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Printed using recycled paper

History of talking-book machines

Early years

The history of talking-book machines goes hand-in-hand with the development of the commercial recording industry. Thomas Edison envisioned recorded books for blind people as a potential use for the phonograph machine he invented. It was not until the 1930s, however, that research caught up with the notion. Edison's first sound-reproducing machines used a vertically moving stylus and rotating cylinders coated with tinfoil, wax, or hard rubber. Each individual cylinder had to be recorded separately. Flat-disc phonograph machines made mass production possible, but the medium had serious drawbacks: the twelve-inch records played for only five minutes per side and were heavy, expensive, and easily broken.

The American Foundation for the Blind (AFB) set out to solve these technical problems. The first machines they developed for the talking-book program used commercially available motors that played at 33-1/3 rpm because motors at that speed were already available for radio station use; ordinary phonographs for music records still played at 78 rpm. Recording books at the slower speed required fewer of the heavy vinylite records.

The first talking-book machines were put into the hands of readers in 1933 and 1934. Such a talking-book reproducer weighed thirty pounds and measured fifteen inches square by eleven inches deep. It was available in either an electrically driven or hand-cranked model. The reproducer was equipped with controls that varied speed, tone, and volume.

WPA program

The original playback machine was produced in quantity under the aegis of AFB for approximately $30 apiece. Before 1935 AFB sold machines to certified patrons, and charitable groups raised money to buy machines for patrons who could not afford them. During the depression years, there were few people who could afford a talking-book reproducer. At that time, AFB recommended that machine production be underwritten by the federal government through its economic recovery program. President Franklin D. Roosevelt expedited the plan to include the project under the Works Progress Administration (WPA). The Library of Congress (LC) agreed to sponsor the project, albeit reluctantly because production and ownership of record players seemed unconventional functions for a scholarly institution.

AFB handled the details of the WPA project, which was set up at a plant in

Acronyms

AFB—American Foundation for the Blind
BPHICS—Blind and Physically Handicapped Inventory Control System
CBMs—cassette-book machines
CD—compact disc
CNIB—Canadian National Institute for the Blind
DAT—digital audio tape
EPROM—electrically programmable read-only memory
ES—Engineering Section, NLS
IFB—Invitation for Bids
IFLA—International Federation of Library Associations
ips—inches per second
LC—Library of Congress
MLAs—machine-lending agencies
NCBI—National Council for the Blind of Ireland
NLS—National Library Service for the Blind and Physically Handicapped
PC—personal computer
QAS—Quality Assurance Section, NLS
RFP—Request for Proposals
RNIB—Royal National Institute for the Blind
rpm—revolutions per minute
TARP—Technology Assessment and Research Program
TBM—talking-book machine
WPA—Works Progress Administration

New York City. Unemployed white-collar workers performed under the direction of a skilled, enthusiastic crew, and the operation soon became very productive.

World War II

World War II brought an increase in talking-book users because of the number of military personnel blinded in the service of their country. LC sent talking-book machines to rehabilitation centers, army hospitals, and prisoner-of-war camps to meet the increased demand. Special arrangements were made so that each of more than 1,000 wounded servicemen could have a talking-book machine waiting for him when he was discharged. The talking book became an effective aid in rehabilitation.

This heightened interest in the talking-book program sparked a reassessment of playback equipment. In 1945 a committee met and suggested improvements in sound reproducers, which were essentially of the same basic design used since 1934. Among new features incorporated were a permanent playing needle, a tone arm that was automatically placed on the record by a push-button control, improved tone quality, standardized parts, and an eight-inch speaker enclosed in the lid of the carrying case.

In the 1950s further progress came in the form of a slower recording speed of 16-2/3 rpm. This speed allowed twice as much material to be recorded on each disc. At the same time, playback machines were designed to be smaller and lighter. The sound quality of the machines also improved greatly during this period, with the introduction of better speakers, needles, and tone arms.

Flexible discs

A new element was introduced in 1968 with the advent of the flexible disc. The first such disc was a recording of the NLS magazine *Talking Book Topics,* which was bound into the large-print bimonthly listing of recorded books. This experimental recording proved popular, and NLS began using flexible discs for other direct-mail magazines in the program. Research showed the new format to be sturdy and inexpensive to produce.

In 1972 NLS produced its first flexible-disc book, Arthur Hailey's *Wheels.* It wasn't long before flexible discs of bestselling books became available. These flexible-disc recordings are produced economically and reach consumers quickly.

An early talking-book machine, model 10 or 11, circa 1935.

Talking-book machines

All program machines are, of course, talking-book machines: they play recorded books for patrons to read. However, the term was first used for record players—the earliest program machines—and it continues to be used to identify those players, as well as being used for program machines in general.

All current models of talking-book machines (TBMs) are capable of playing rigid and flexible discs at 8-1/3, 16-2/3, and 33-1/3 rpm (revolutions per minute). These machines are not equipped with a battery and can be played only when plugged into an electrical outlet. The newest model, the A-1, includes a variable-speed control; earlier models do not. TBMs are designed so that eligible readers may play any disc materials available to them including sources other than NLS.

Overseas talking-book machines are identical to the standard TBMs except that they contain a rechargeable battery and have a variable-speed control. The overseas machines can use 110–120 or 220–240 volt current. These machines are loaned only to American citizens who live in countries using the higher voltage.

Cassettes

In the late 1950s and early 1960s, even before a proven system was on the market, NLS began research into cartridge tape systems suitable for the talking-book program. The goal was to design an easy-to-operate, inexpensive, lightweight machine that could play tapes housed in a cassette that did not have to be threaded like an open-reel tape. To avoid copyright infringement problems, NLS wanted a special format that would prevent tapes from being copied and used by noneligible persons.

Early prototypes were tested in the 1960s, but they were too complex and required many adjustments for successful operation. By 1968 tape cassettes and players were widely available commercially and at a low cost. NLS field tested machines that operated at 1-7/8 ips with tape recorded on two tracks. The responses were so enthusiastic that NLS added cassettes to the talking-book program shortly thereafter. The greater portability of the cassette players and their low cost compared with talking-book machines made them very attractive. It was possible to envision that the talking-book program would soon concentrate on cassettes rather than on rigid discs and to focus research activities accordingly.

By 1971 NLS began circulating books on cassettes throughout the regional library system. NLS purchased commercially produced cassette players modified to play two speeds (15/16 ips and the commercial standard of 1-7/8 ips). The players were adapted for monaural rather than stereo playing and marked with raised characters for ease of operation by blind people.

By 1973 demand for players quickly exceeded supply, and NLS procured 30,000 machines built to its own specifications. The new C-73 used a four-track system that allowed for six hours of playback time per cassette. The machine accommodated tone-indexed tapes and had a built-in AC adapter.

The 1970s saw the development of further enhancements to the cassette machines: an automatic-reverse cassette deck, recessed switches, and a tape-motion sensor that shut off the machine when the cassette take-up reel stopped. Engineers also developed a number of accessories such as a solar power panel, a remote control switch, an extension lever system to allow easier operation for persons with limited manual dexterity, and headphones for private listening.

A study conducted in 1974 recommended the full conversion from rigid discs to cassettes and flexible discs. The gradual phaseout of rigid discs began in 1978 and was completed with the production of the last rigid disc book in 1986.

By 1981 NLS contracted for the C-1 cassette machine, which was similar to previous models except for minor modifications and improvements. The machine features fast-rewind and fast-forward capability, end-of-tape sensors, a switch that allows the reader to select which of the four tracks should be played, a variable-speed control, and tone and volume controls.

E-1 (Easy) cassette machine

In 1977 NLS conducted a study of blind and physically handicapped persons who were eligible to use the talking-book program but did not participate in it. The survey con-

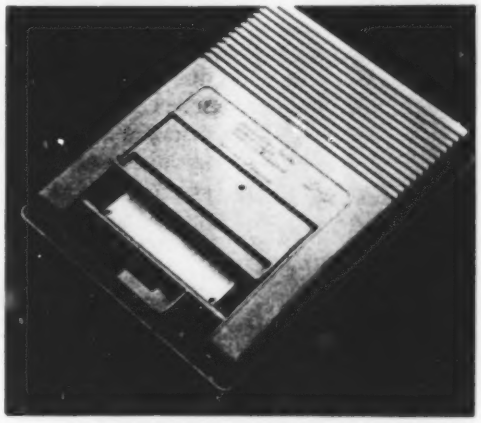
Cassette machines

These are portable playback-only units capable of playing two- and four-track cassettes at 15/16 and 1-7/8 ips (inches per second). They are equipped with a rechargeable battery and a variable-speed control. Standard cassette-book machines (CBMs) enable readers to use materials recorded in commercial as well as NLS formats.

Overseas cassette machines are identical to the standard cassette machines except that they operate on 220–240 volt current as well as on batteries. The machines are loaned only to American citizens who live in foreign countries using this higher voltage.

E-1 (Easy) cassette machine
This machine is extremely easy to understand and to operate. It is smaller than the standard cassette machine and will operate only when plugged into an electrical outlet. There is no battery.

When the cassette is placed in the machine, it rewinds to the beginning of side one and begins to play automatically. If undisturbed, the machine will switch sides when necessary, playing all four sides with a single insertion. During this process, the tape may be stopped at any point by sliding back the cassette door, moving the volume control to the "off" position, or unplugging the machine. The machine will resume playing at the same place on the tape when the cassette door is closed



again, the volume control is moved to the "on" position, or the machine is reconnected to an electrical outlet.

cluded that many eligible persons did not use the program because of disabilities that prevented them from operating a cassette player. A further study in 1981 stated that many elderly persons felt they could not manipulate the controls of the machine.

NLS began developing a simplified cassette machine named the E-1, or easy machine, in 1980. Production difficulties delayed release of the machine, but in 1985 the first 1,000 E-1s were issued for field testing. By 1986 the E-1s were in full production, and 40,000 of these simplified machines were made available to readers who were unable to operate the standard players or were uncomfortable with their operation.

The E-1 represents a revolutionary departure from previously produced cassette players. It has only two main controls—a sliding switch and a push button, both located at the front of the machine. Moving the sliding switch to the right starts the tape and selects the volume. Thus stop, play, and volume are combined in a single control.

Although simple to operate, the E-1 is actually a very complex instrument that uses microprocessor technology to control the various functions.

Combination machine
This machine can play both cassettes and discs. For playing cassettes, it offers all features of the standard cassette machine. It can play both two- and four-track cassettes at 15/16 and 1-7/8 ips. The machines will, if the reader chooses, switch sides of a cassette automatically.

For playing discs, the combination machine has several features not found on the standard TBM: variable-speed control, fast forward, and rewind. The tone arm is equipped with a device for locating the edge of the disc and the grooves leading to the edge of the recording. The tone arm cannot be raised; it is removed from the disc by pressing down, which retracts the needle, preventing damage to the disc. This tone arm design makes it possible to close the cover of the machine with very little change to the needle's position on the disc.

The combination machine weighs approximately fifteen pounds and comes with or without a rechargeable battery.

Combination machine

NLS began studying the feasibility of producing a machine that could play both cassettes and discs as early as 1973. Such a machine would be ideal for persons with limited space who needed both playback capabilities. Work on the design and engineering of such a machine began in 1977, and a rough prototype was available the following year. Before going ahead with further work on the combination machine, NLS decided that developing the E-1 machine should take precedence, partly because the combination machine would use some technology being developed for the E-1.

Many modifications were made to the original design of the machine as a result of extensive field testing by patrons from regional and subregional libraries. The machine's electrically programmable read-only memory (EPROM) microprocessor chip was adjusted to meet the needs of readers, and other suggestions have affected the machine's design. The first production models of the combination machine were released in 1992.

—George Thuronyi

Accessories

Accessories are provided for patrons who need additions or modifications to program machines. The following accessories are currently available.

Amplifiers. Special amplifiers are available to eligible readers with a significant hearing loss. Because the sound is boosted to a level that could cause permanent hearing loss to a person with normal hearing, a separate application requiring medical certification is necessary. The amplifier is designed to be used in conjunction with NLS headphones on any kind of NLS playback equipment. Issuing and inventory control are handled directly by the NLS equipment control officer.

Headphones. Headphones are available to persons who require them to use the service without disturbing others—for example, persons in institutions, students, those in community-living situations, and others with demonstrated need. Distribution of headphones is restricted to patrons who would be unable to use the service without them. The model 510 headphone must be used with the amplifier.

Pillowphones. A pillowphone, to be placed under the reader's pillow, is available for those handicapped persons who read in bed. The sound normally can be heard only by the reader. The pillowphone can be used with any kind of NLS playback equipment.

Extension levers. Extension levers are provided for cassette readers who have difficulty manipulating the key controls on the standard cassette machine.

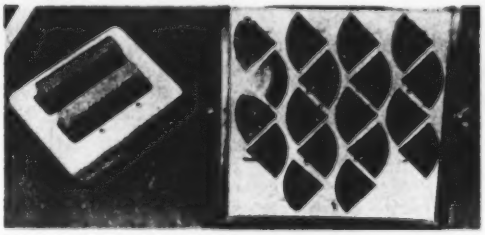
Solar panels. Solar panels are used to recharge batteries for the standard cassette machine. Panels and accompanying battery packs are available on permanent loan to patrons living in areas without electricity or on a short-term basis for trips to wilderness regions.

Remote control and breath switch. These devices are for readers with limited manual dexterity. The remote control turns machines on and off. The breath switch is an option.

Extension levers

Pillowphone

Amplifier and headphones

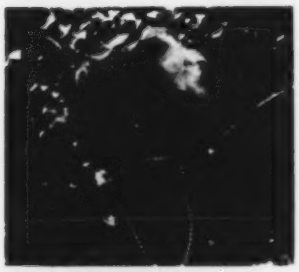


Solar panel with battery pack

Remote control and breath switch

Users speak out

Patrons quoted in this article include



Gloria Sussman

Bruce Spiro

John Bogert

Since the talking-book disc player was introduced to the NLS program in 1934 and the cassette player was issued in 1971, they have been regarded as the most basic and tangible program element to the readership of now more than 700,000. Both machines have undergone considerable technological change, generally becoming smaller, lighter, and more exactly tailored to the needs of visually and physically handicapped individuals.

For many patrons, these machines still provide their primary source of information and communication, and the standard cassette player is the machine of choice.

In interviews, several patrons indicated that they use the disc player primarily for reading magazines and would rely totally on the cassette player if magazines were recorded on cassette. They also believe, however, that the wide selection of magazines available to them makes having the disc player worthwhile.

Patrons all strongly value the cassette player, especially its portability. They enjoy being able to move it from room to room in their homes and to use it outside in the backyard or park. They also use it while traveling locally and on vacation. One patron took her cassette machine with her on a trip to Europe.

"I am in my late sixties. I lost my sight in my mid-fifties, and I feel I should have learned braille. Since I didn't, I have to rely on listening so much and I am interested in so many things," said Gloria Sussman, a retired music teacher. "The cassette player is my lifeline."

The patrons interviewed use their cassette machines to fulfill a variety of reading needs including leisure and recreational reading, which covers a wide range of subject areas. Says Bruce Spiro, a retired computer security consultant, "This program is a godsend. I just don't know what I would do if it didn't exist."

Employed patrons find the machine helpful in reading work-related material, and some even have their cassette player at work. Katie Bunnell, a part-time library aide at an NLS subregional library, talked about how important and helpful it is to be able to refer to recorded memos, regulations, letters, and other documents.

Other reading preferences cited included current events, such as professional journals and magazines; community and social information, including organizational newsletters and notes from meetings; study and instructional materials, textbooks for courses, music instructions, and recorded instructions for new appliances or other items.

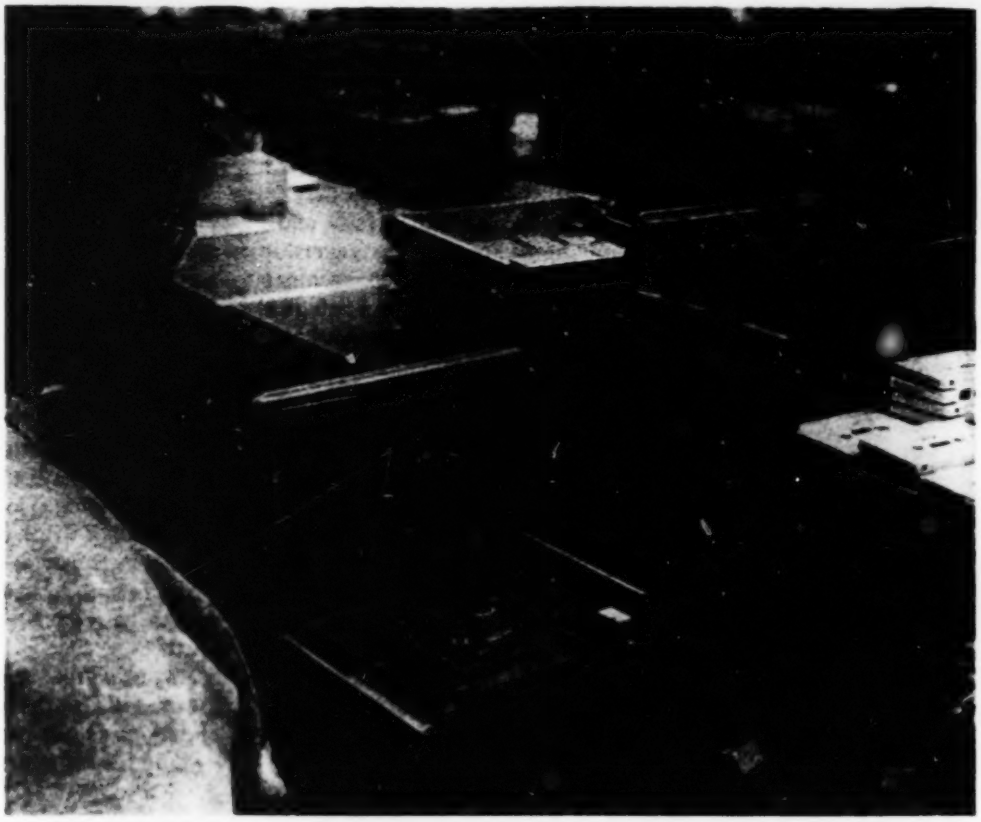
A data analyst for the Goddard Space Flight Center, John Bogert, pointed out that, while not all his reading materials come from the talking-book program, it is because of the program and its playback equipment that patrons have access to such a large assortment of information. Says Bogert, "There is always a benefit to having access to information. The exposure to information can be used in all aspects of life, including work. It gives you a resource to the world. Well-formatted material is invaluable for checking references and understanding context."

Most patrons said they use their equipment daily, for an average of three to four hours. Says one patron "I am not sure how I would fill my hours without talking books."

—Freddie Peaco

About patrons and machines . . .

- Patron needs and attitudes are fundamental to the planning and development of all NLS materials, including machines. Therefore, patrons are constantly involved in the process through surveys, membership on advisory committees, and testing of prototypes, as well as through informal feedback to network library staff.
- NLS patrons read an average of thirty books a year—many times the average for print readers.
- Almost all patrons who read recorded materials use cassettes or both cassettes and discs; only 21,000 readers are listed with only talking-book machines.
- Most active readers use their machines several hours each day, not only for NLS books and magazines but also for study and for professional and recreational materials from other sources.



C-1 cassette machine being assembled. Production photos show procedures at Telex Communications, Inc., in Blue Earth, Minnesota, an NLS contractor. Photos by Gary T. Sands.

Where do talking-book machines come from?

From reflection to reality

To begin with, there's a concept—an idea for a new product or an improvement of an old one. It's not easy to generalize about original thinking, the sources of invention, the origins of ideas—these are underlying questions about the nature of human creativity that have vexed philosophers and social thinkers since antiquity.

In science and technology, ideas seem to emerge from an interplay among the patterns of existing inventions and standard techniques, the definition of needs (whether emergent or long-felt), the reach of the imagination, and the limitations of available resources, whether material, technical, or intellectual. Of course, within formal institutions, the dimension of administrative regulation must also be factored in; it is often the degree of regulation that differentiates the production patterns of government agencies from those of private industry and the individual entrepreneur.

Once an idea, a concept, for a machine is brought forth (or, for that matter, for any item of equipment, from solar panels to mailing containers), a set of steps will follow, each hedged about with formalities, regulations, and procedures that must be adhered to. These steps are conceived to guarantee the highest quality of material production at the lowest cost possible—cost ultimately borne by the American taxpayer.

These procedures may be time-consuming; on occasion they may seem maddeningly frustrating—both to designers in the NLS Engineering Section who are eager to see their ideas implemented and to consumers who are eager to benefit from the advances that will be embodied in the new product—but their purpose is sound. Long-range prospects as well as short-term benefits must be taken into account; contemporary options must be assessed against the perspective of future potentialities.

Rigorous adherence to high standards of development, production, and testing are built into the NLS program's mandates and traditions. Twenty years ago, in an encyclopedia of library science, the evolution of NLS machine-production philosophy was summarized in this way:

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An NLS patron tries the controls of an early prototype of the easy (E-1) machine.

"In addition to the development of specifications for machines, records, and needles, the National Bureau of Standards (from 1948 to 1957) and the Technical Section of the National Library Service for the Blind and Physically Handicapped (from 1957 to the present) ... maintained a continuing investigation of the whole field of sound recording—tape recording, wire recording, and recording on film—for possible application to the talking-book program.... Since 1967 [NLS] has had its own research and development sections with a technical staff and an anechoic chamber for checking machine performance.

"As a result, a uniformly high quality in equipment for the talking-book program can be maintained, since specifications have been established to which all bidders must conform. These specifications, compiled with the aid and advice of engineers, are subject to continuous revision. Bidders are required to submit prototypes of equipment ordered, and these undergo inspection and testing before purchase and authorization of delivery to the distributing libraries are granted by the Library of Congress."

Production steps

What follows is an outline of the progress a machine must make in order to be transformed from a mental representation to a finished product.

Photo by Yusef El-Amin

Bob Mainhart, Quality Assurance specialist, electronic products, tests a cassette machine in the NLS QA laboratory.

- **First specifications created.** NLS engineers create a set of specifications for a product that does not yet exist or that requires modification. No equipment is ever manufactured without specifications that precisely define the equipment's functions, basic design, capacities, and limitations. A cassette machine, for example, must be two-speed, four-track, compact, lightweight, sturdy and durable, capable of sustaining punishing vibration, easy to use, relatively simple to repair at the first echelons of maintenance, and capable of meeting the reading requirements of patrons. Certain exclusions may also be written into the specifications. NLS cassette machines, for example, do not need recording heads; frequency ranges for talking-book playback do not need to be as wide as those called for in commercial audio engineering dedicated to the flawless reproduction of orchestral music.

Engineers also produce blueprints and drawings.

- **Bids solicited.** Manufacturers are invited to consider the specifications and submit estimates of their abilities to produce the product, including projected time and cost structures. Competing bids are scrutinized, and a contract is awarded to the lowest, responsive, responsible candidate. In practice, the elapsed time between the advertisement of a carefully defined solicitation and the award of contract needs to be at least six to eight months.
- **Contractor submits design proposal.** A long collaborative process begins between the contractor and NLS, handled primarily by the Engineering (ES) and Quality Assurance (QAS) sections. Working closely together, they develop a design that conforms to the original specifications, taking into account the availability of product components and other pragmatic aspects of production.
- **Prototype built, tested.** When an acceptable design is agreed upon, the contractor produces a working production-control model. "Getting from approving a design to coming up with a functional prototype may turn out to be a long and arduous phase of the overall process," says Don Smith, assistant head of QAS. "There are hundreds and hundreds of things that can go wrong."

The prototype is rigorously tested for every parameter called for in the specification, with special attention to electrical functions and operability.

• **Samples manufactured.** After all changes have been approved and accepted and the prototype's quality has been tested to the satisfaction of all parties, the contractor is authorized to produce two production-control models. "Mass production has inherent problems, too," says Smith. This step ensures that the contractor has the capability to inaugurate a workable production line. After these production-control models have been warranted through testing, the go-ahead is given to produce a sequence of 200 samples.

• **Samples tested.** All 200 sample models are tested as scrupulously as the prototypes. "NLS testing is more rigorous than the testing of any consumer product comparable to ours," says Smith. This phase represents an examination not only of the individual pieces of equipment, but also of the manufacturing process itself—the contractor's speed, efficiency, and ability to maintain the highest quality and respond appropriately to complications. The appearance of numerous problems—irrespective of their particular urgency or gravity—will itself be construed as a kind of warning signal.

• **Begin manufacture of product.** If all 200 samples and the process itself are found acceptable—in a "best-case scenario"—manufacture of the finished standard product may begin. Even at this point, however, quality assurance procedures will not be relaxed. The product will be randomly sampled for the duration of the production period; the manufacturer's own inspection procedures are closely monitored.

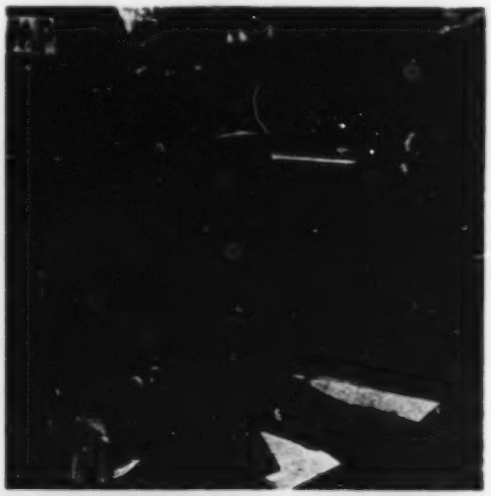
Ongoing production

In an average year, NLS produces approximately 60,000 standard machines to meet the demands of the program.

Robert Kost, head of QAS, says, "The specifications list all the technical requirements and identify all of the tests that must be performed on incoming inspection and in-process production. The technical requirements are things like frequency response, output, wow and flutter, torque, and audio quality." The machines are "cycled to make sure there are no intermittent problems. We expect every function to work."

Manufacturers deliberately maintain production lots at a manageable size to reduce the possibility of an insidious intrusion of quality defects. Levels of quality may shift "spontaneously" during manufacture, and inspection requirements may therefore be adjusted or intensified in response. Problems unanticipated even during the extensive laboratory and pre-manufacturing tests may appear, and production may be halted while such problems are addressed.

Assembling the tape motion wire (left) and riveting the door strap to the bottom of the case (right).



Above, speakers are installed (left) and the cords are assembled. Warranty testing and repairs are shown at the right.

Troubleshooting

After the machine has been in circulation for some time, complaints may begin to appear from patrons who have used the equipment in ways that were not foreseen or simulated under test conditions. An item that has gone out of production for a period of time must be watched with special care when production is resumed; any number of conditions might have changed during the interval of inactivity.

"After we approve the lot, we also require manufacturers to send us one overpack—four machines—out of every day's production," says Kost. At NLS, each machine is tested for problems caused by mailing: "This shows how the patrons receive the machines. If the machines get to us okay, we feel pretty confident that our machine is able to go through the mail okay."

Kost states, "Only lots that are approved by NLS inspectors are shipped to the network. Every machine has a stamp on it to show it's been through all of the tests."

QAS also maintains warranty reports for machines that are returned because of mechanical problems. "We list all the problems—the reasons they were sent back—and we keep these in a priority order." The log is then used to make improvements in the machine design.

Smith stresses that Quality Assurance does *not* "test quality into a product." No product with known defects or inadequacies is ever permitted to move beyond the design stage in the expectation that its flaws may somehow be remedied in the course of the testing process. Testing is carried out to discover and remove practical problems. "We're not trying to build a product that will do everything for everyone," Smith says, but rather to produce "a product that does exactly what it's supposed to do, predictably and well."

—Ed O'Reilly

The contracting process

Government regulations applicable to the procurement of materials and services are widely understood to be a labyrinth from whose intricacies even intrepid adventurers may fail to return. Nevertheless, according to William Price, head, NLS Administrative Section, the *Federal Acquisition Regulations*—the set of rules by which procurements are arranged—do work. They may be cumbersome and a little tricky sometimes, but they do provide for the fair and orderly transaction of contractual arrangements between the government and the private sector.

Legions of administrative procurement contract specialists are trained and employed by the federal government. Personnel whose main role is contract oversight are assigned not only to the NLS Administrative Section and the Office of the Director, but also to most of the quasi-autonomous NLS sections. Contracts must be not only properly solicited and awarded, but constantly monitored as well. On those occasions when conflicts, discrepancies, or errors arise, grievance and termination procedures must be observed with minute correctness. The Library of Congress Contracts and Logistics Division handles all contract procedures.

Solicitations are widely advertised.

Manufacturing capacity

The central and compelling reason for the existence of an immense, sprawling contracting apparatus is simple: the federal government has virtually no manufacturing capability of its own. The government is not in the business of production, but calls upon private industry to meet all of its material needs and many of its conceptual, creative, design, engineering, logistical, and mechanical needs as well.

Talking-book machine manufacture is a small and specialized enterprise, with only a limited number of potential suppliers. Audio equipment manufacturing capability in general emigrated from these shores starting more than two decades ago, so that, as Price says, there is "no significant commercial cassette machine manufacturing in the United States today."

With a narrow field to choose from, the job of contracting for talking-book machine production is somewhat simplified—but not much. Those manufacturers who are functional might not have the full capability to consistently produce the number of machines needed at exacting NLS specifications; and, of course, a manufacturer with the capability might not seek out a government contract. Government quality requirements are precise, and NLS's quality requirements are high even by government standards. An NLS contract is not a sinecure, and successful adherence to its terms may challenge a vendor in many ways.

Solicitations

A solicitation is written when a need for manufactured goods or for product development has been identified. The solicitation contains a description of what is wanted (i.e., a certain number of machines meeting certain specifications of kind and quality to be produced within certain time and budgetary constraints; or, the actualization of a certain not-yet-existing product according to particular guidelines) together with a description of the process and standards by which bidders will be evaluated.

There are two kinds of solicitations: an Invitation for Bids (IFB) and a Request for Proposals (RFP). In general, an IFB is used when the exact end product is known—equipment with existing standardized capabilities and designs (machines already produced and with specifications in place); an RFP is issued when the end product is envisioned (a possible mailer for cassette magazines or braille books) but the soliciting agency is not certain as to production methods to be employed, or wishes to ensure that all of a bidder's technical capabilities are demonstrable before the contract is awarded. With an RFP, the bidder's physical plant, equipment, existing products and

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procedures, track record, and any other pertinent factors are all susceptible to scrutiny and evaluation.

Following consolidation and approval by the NLS contracting officer at the LC Contracts and Logistics Division, NLS solicitations are published in *Commerce Business Daily*; they are also uniformly circulated to known potential vendors at the recommendation of the soliciting agency. For example, there are only a handful of large-scale braille production agencies in the United States, so NLS would normally include them on a standard bidders list.

Once the bids or proposals from vendors have been received, they are evaluated: graded and scored numerically, point by point. With respect to NLS machine production, this part of the process is undertaken by the technical staff—members of the Engineering and Quality Assurance sections. Evaluators receive all the pertinent information submitted by bidders *except* the price structure. When bids and proposals have been scored, the bids are returned to the LC contracting officer, who makes a final determination and awards the contract.

Contract termination

Contracts may come to an end for several reasons. Most contracts, of course, simply run their specified course. A contractor that fails to provide the finished products for which it has obligated itself in a timely way or at the specified level of quality may be found in default and the contract terminated for this reason. The phrase "at the convenience of the government" covers a multitude of justifications for termination, including a dismal outlook for a vendor's capability following repeated quality assurance rejections, or the cessation of need for the vendor's product.

Competitive process

Is there a way for a successful contractor to guarantee an ongoing relationship with the government? The short answer is no. Some contracts may be written with renewal options if a project is of long duration, the requirement is recurring without change, and disruption can be shown to be highly disadvantageous—i.e., costly. This has been the case with some machine production agreements, particularly where development is a factor in the contractual arrangement and considerable time-consuming testing and evaluation is expected. As a rule, however, the solicitation of competitive bids must be repeated at the expiration of any contract, regardless of the vendor's level of success.

"The competitive bid process is the basis of government contracting," says Price. "The process keeps the producers competitive and honest."

Procedures developed through close collaboration with a government agency may, of course, enable a contractor to consistently advance successful bids—but this is a function of the competitive process and not a disadvantage to it.

When a vendor is the sole source for a product or service, government auditing must be engaged to ensure that all issues of quality and cost-effectiveness are addressed in a satisfactory way. Audits may be thought appropriate to "keep a sole-source vendor in check"—that is, to preclude possibilities of exploitation or abuse, whether inadvertent or otherwise.

On the whole, whether because of or in spite of the regulatory structure, relations between NLS and the producers with whom it has engaged have generally been good. Adherence to an ideal of reciprocal benefit, sought for in any contractual arrangement, has been close, with responsiveness to emergent needs high on both sides.

—Ed O'Reilly

Photo by Yusef El-Amin

William Price, head of the NLS Administrative Section, at contract files. The NLS appropriation of $42,713,000 for fiscal year 1994 provided $10,377,000 for machine production.

Inventory and maintenance

To meet the needs of a readership of more than 700,000, an adequate supply of machines must be constantly available. Currently, the NLS machine inventory consists of approximately one million cassette and disc players valued at more than $90 million.

"Machines are generally in one of three categories," explains Steve Prine, head of the NLS Network Services Section. "They are either assigned to patrons, available for use, or in repair." NLS has been lending machines to patrons since the late 1940s. Patrons may keep the machines as long as they are actively using the service, but the machines remain the property of the government.

Machines are distributed to patrons around the country through machine-lending agencies (MLAs), most of which are located in regional libraries. Many patrons have both talking-book and cassette machines, giving them greater flexibility in the types of material they may select. NLS produces most books in cassette format; recorded magazines are produced on flexible disc, along with approximately 100 popular books annually that are expected to be in immediate high demand. The collection also contains many older books that were produced on rigid disc before that format was phased out.

Maintaining a proper inventory of machines depends on several factors: production of a sufficient number of new machines of various types on a regular basis; repair and maintenance of older machines; correct assignment procedures in the network; and careful tracking procedures both at NLS and in the network.

Production. Production depends on long-term planning to determine the type and amounts needed for particular machines each year, plus contracting steps to ensure the availability of a producer (see articles on pages 8 and 12). The most essential requirement is adequate annual funding by Congress. Funding for FY93, the most recent year with completed records, permitted production of 45,000 cassette machines and 12,000 talking-book machines.

Repair and maintenance. Most current NLS machines are under warranty by the producer for three years, and the warranty for the C-2 cassette machine now going into production will be five years. During this time, the producer is responsible for any repairs or adjustments needed. Any production problems should be discovered and corrected during this period.

NLS machines are designed for an average life of ten years, with normal use and occasional routine maintenance such as cleaning, replacing the battery in some machines, and making other minor adjustments or repairs. Machines must be returned to the machine-lending agency for repair.

Some network libraries have staff members responsible for repairs, but the bulk of repairs for talking-book and cassette machines are done on a volunteer basis by Telephone Pioneers, an organization of senior and retired telephone company workers. Pioneers began repairing machines at two locations in 1960 as a pilot program, and the service rapidly spread throughout the country. In 1990 the Pioneers national organization, whose chapters perform a number of other volunteer activities largely related to sound equipment, adopted the NLS repair service as their only national program. Pioneers coordinators for each region meet annually with NLS staff, and Pioneers representatives also serve on the NLS National Audio Equipment Advisory Committee. The Pioneers also operate a parts-reclamation facility in Arizona, where usable parts of unrepairable machines are salvaged. Reclaiming parts not only saves on repair costs but provides parts no longer available for older machines.

In 1989 the Elfuns, the General Electric Company's counterpart to the Pioneers, also undertook machine repairs in some parts of the country. Elfuns had already logged 1,000 repairs in Albany, New York, when they officially joined the program.

The volunteer repair activities are estimated to have been worth millions of dollars over the Pioneers' thirty-five-year relationship with NLS. (Repair records are kept for individual machines, but are not tabulated for cost equivalents.) Approximately 1.3 million machines were repaired during the first thirty years of the program.

NLS has also contracted for some repair services through private companies, both to handle repair backlogs at some MLAs and to determine costs for commercial repairs.

Assignment of machines. Machines produced by NLS are allotted to MLAs accord-

Members of the Telephone Pioneers Lonestar Chapter #22 (Dallas, Texas) at work repairing machines in 1981. Volunteers have repaired nearly 2 million machines since the Pioneers program began in 1960.

ing to the number of patrons served. Says Steve Prine, "MLAs usually maintain a three-month supply of machines, based on anticipated patron usage." The supply consists primarily of talking-book machines and cassette machines, but there are also smaller numbers of special-purpose machines. MLAs are required to store the machines in their inventory in a secure location.

Staff of the MLAs are responsible for issuing to patrons the machines that will best serve their needs, which means, in most cases, a cassette machine and a talking-book machine. Patrons who find the standard cassette machine too complicated are assigned the E-1 (Easy) cassette machine but may also use the talking-book machine for magazines and books produced on disc. Patrons who have the combination machine have the capacity to play both formats and do not need a second machine.

Produced machines are available for issue to patrons, as are machines that have been repaired. Current NLS guidelines stress issuing the new machines first to get them into the hands of patrons during the warranty period. All other machines should be repaired when possible as backup; only a few models for which parts cannot be obtained can be considered obsolete.

Tracking machines. Inventory procedures are difficult for such a large number of machines distributed to agencies and then to individuals throughout the country. But there are procedures for all locations and categories, and every attempt is made to track the status of each piece of government property. MLAs are provided with a manual entitled *Machine-Lending Agency Inventory Procedures Manual* as a guide to inventory control and reporting.

Using serial numbers, NLS tracks machines issued to MLAs through its BPHICS (Blind and Physically Handicapped Inventory Control System) automated database. MLAs are responsible for tracking machines assigned to patrons, ready for issue, or in repair. They are also responsible for checking whether patrons remain active—that is, they read at least one NLS-produced book or magazine each year. Inactive patrons are requested to return their machines for reissue to active patrons.

Machine reports are sent to NLS each month indicating any change in status for particular machines. MLAs also perform regular patron audits, using a sampling of patrons to verify their records as to the types of machines on loan and their serial numbers. Since most patrons cannot see the serial numbers, verification is not easy; to help in this process, newer machines will have the serial number located where it is easy to find and printed in large enough type for partially sighted people to read.

Outside audits are conducted periodically. The Inspector General, Library of Congress, mandated the most recent one, which began in September 1992 and was conducted by a firm under contract to the Library. Procedures included two-person teams that spent up to three days at each of the network's sixty MLAs checking records and contacting randomly selected patrons for verification.

NLS consultants visit each MLA every two years to evaluate its activities against the American Library Association's standards of library service for blind and physically handicapped persons. Written reports, sent to both MLAs and their administrative agencies, are prepared for comment and response.

Ultimately, responsibility for tracking machines rests with NLS, which monitors procedures at MLAs and provides guidelines and help as needed.

—Vicki Fitzpatrick

Nations cooperate for compatible talking books

International cooperation in the exploration of future talking-book technology may bring long-sought global compatibility in playback equipment.

Efforts to increase the universe of available special-format reading materials have in the past been hampered by the lack of information about recorded and braille books and by the fact that different countries use different recording systems. Currently, progress toward a union catalog is alleviating the first problem, and agreements to share information and experiments may eliminate the latter.

Like agencies in many countries, NLS has a policy of lending any book it has produced to any library in the world that serves blind and physically handicapped readers and of actively seeking a source for borrowing a recorded book, no matter what language, for any of its patrons. In addition, NLS purchases recorded books in English from Britain, Canada, Australia, and New Zealand and books in foreign languages from a wide range of countries. Other countries purchase special-format books made for NLS from the producers through an arrangement that protects copyright considerations.

But the usefulness of international loan, purchase, or exchange is limited by the barriers of technological incompatibility. NLS talking-book technology has progressed to the use of the compact format of four tracks at 15/16 inches per second. Other countries use other formats, many relying on the commercial two-track format at 1-7/8 inches per second.

International meetings

NLS has been urging standardization of talking-book technology for twenty years. In a 1977 meeting of the International Federation of Library Associations (IFLA) in Brussels, NLS director Frank Kurt Cylke proposed that IFLA serve as the coordinating body for the development of international technical and service guidelines in library service to blind and physically handicapped people. IFLA established a Section of Libraries for the Blind, which became a forum in the drive toward standardization.

In April 1990, directors of four major agencies met in Dublin, Ireland, to pursue this goal. The agencies were the Canadian National Institute for the Blind (CNIB), the National Council for the Blind of Ireland (NCBI), the Royal National Institute for the Blind (RNIB) of Great Britain, and NLS. They agreed that it would be financially and technologically wise to work together to improve current systems but at the same time to take advantage of new technology that could be used in producing audio books and magazines.

Representatives from Canada, Great Britain, Ireland, and the United States met in Dublin in 1992 and reaffirmed cooperative efforts. John Cookson, head of the NLS Engineering Section (standing, third from left), presented the proposed NLS Technology Assessment and Research Program (TARP) for future audio development.

RNIB and NLS, whose current systems are incompatible, agreed to a full exchange of information. In addition, the group set up a structure to facilitate interchange and development. (See *News*, Vol. 21, No. 2, April–June 1990.)

In August 1990, Henry Paris, then chief of the NLS Materials Development Division, presented a paper titled "Interlending: A Call for Format Standardization" at the annual conference of IFLA in Stockholm. The paper, coauthored by Tom Martin, then head of the NLS Network Services Section, called for international cooperation in the development of standards aimed at increasing compatibility of talking-book systems. It stressed the importance of establishing broad basic requirements with nonrestrictive standards that would not rule out future technologies.

NLS argued that international standards should be set now, so that countries that are developing new systems could incorporate those standards. The authors called on agencies worldwide to share explorations of new technologies. To allow time for this sharing, NLS pledged to maintain its current system for at least a decade (until 2000).

At the 1991 IFLA meeting in Moscow, Paris presented an update on the progress made in a paper titled "The Sharing of Special-Media Materials among Libraries: Sale, Loan, Exchange, and Gift." The paper, coauthored by Tom Martin and James Herndon, NLS foreign-language librarian, again called for international compatibility.

At the 1991 conference, Paris also set the tone for future development when he presented the paper "The U.S. Talking-Book System: Current and Future Requirements." In this paper, he surveyed the current talking-book system and laid out some requirements for a future system. He invited other countries to provide details of the requirements of their systems and called for cooperative development of specifications that will allow for exchange among the world's talking-book producers.

In November 1991 NLS hired John Cookson to head the Materials Development Division's Engineering Section and charged him with investigating the most appropriate technologies for the future talking-book service. At a second Dublin conference in April 1992, he presented a paper on the proposed NLS Technology Assessment and Research Program (TARP), and the agencies reaffirmed cooperative efforts. (See *News*, Vol. 23, No. 3, July–September 1992.)

The agencies agreed that a common format for international exchange was necessary and the format would utilize digital technology. They projected that research would continue over the next five years and noted two efforts then underway: RNIB's investigations into compact discs and NLS's initiatives in digital format recording.

The latter project began in 1985 when two NLS producers, the American Foundation for the Blind and the American Printing House for the Blind, started using digital techniques for mastering new recordings. This technology has been used mostly for books of lasting interest, and, to some extent, for restoring old recordings.

Michael Moodie presented Cookson's TARP paper again at the IFLA meeting in New Delhi, India, later in 1992.

Oversight of developments

Representatives of the four countries—Canada, Great Britain, Ireland, and the United States—who pledged themselves to information exchange and technical cooperation at the 1990 meeting in Dublin, Ireland, are serving as an oversight group for monitoring developments internationally, with special attention to work ongoing at NLS under the TARP program. They have since been joined by Australia, New Zealand, Spain, and Sweden. The expanded group will meet in Toronto, Canada, in April 1995.

The cooperation shown so far among agencies engaged in experimentation with new technology indicates that compatibility may become a reality early in the next century.

—Ruth Nieland

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NLS technology and research look to future

Technology Assessment and Research Program

A Draft for Discussion

March 27, 1992

The wide-ranging Technology Assessment and Research Program (TARP) forms the basis for exploration. NLS engineers are currently concentrating on digital original mastering.

The current explosion of communications technology has opened fantastic opportunities for talking-book enhancements. Options now possible include using verbal commands to control playback machines, searching back and forth throughout a recorded book at will, indexing at levels previously considered impossible, varying the speed of narration without pitch distortion, storing whole books on cards the size of a 35mm slide, and transferring books over the telephone.

Of course, NLS cannot browse through these possibilities plucking features at will. Changing the talking-book technology will mean replacing a $300-million investment in machines and reading materials and tampering with a system that 700,000 blind and physically handicapped readers know and like—a system embedded in a network made up of local librarians, volunteers who repair machines and record materials locally, and the U.S. Postal Service.

In addition, a long list of other requirements and constraints has been identified: there must be the possibility of exchanging materials with other countries; local organizations must be able to use the technology to produce books in small quantities; the machines must be maintainable by local staff and volunteers; controls must be usable by both blind and physically handicapped readers; materials must be able to be stored and shipped safely and economically; input from consumers and network librarians must be incorporated; and the technology must be economically feasible, open to further enhancement, and not likely to become obsolete in a short time.

The diversity and breadth of technology now appearing and the speed with which it is developing add still more complexity to the researchers' tasks. If the current system isn't broken and if fixing it is so complicated, why not leave it alone? NLS is being both pulled and pushed toward change: pulled by the lure of offering features long desired but previously out of range technically, and pushed by the fear of dependence on its current technology that will become increasingly expensive, if not unavailable, as it fades from the commercial scene.

Faced with the technological opportunity and the time to think about it, NLS issued announcements and invitations both within NLS and among related agencies and organized its Technology Assessment and Research Program (TARP) team in September 1992. The team includes thirteen NLS staff; representatives of the consumer groups American Council of the Blind and National Federation of the Blind; and representatives of Recording for the Blind, the main U.S. producer of textbooks, whose patrons often use NLS playback equipment.

On a planned timetable, the team members, especially those of the NLS Engineering Section, are researching available technology, conducting experiments, and building models. They are writing and publishing papers and soliciting input in various forums from as wide a range of researchers and users as possible. The team meets regularly twice a year.

Experimental models

Currently the NLS Engineering Section is developing experimental models for digital talking books. The engineers expect to have an experimental digital talking book in place by 1995. It will be installed in a personal computer (PC) so that engineers can easily use it to experiment with other technical challenges such as advanced indexing schemes and variable-rate playback without pitch distortion.

The engineers are also developing other PC-based software components for future equipment. These components can be experimented with and perfected, then coded in a compatible computer language and put together in a future talking-book machine.

Experiments are also underway to determine the advantages of different techniques of compressing audio data for storage and delivery and then decompressing it for playback. Such techniques may reduce the size of a data file by a factor of ten. The experiments are expected to yield equipment and software specifications that can be used to develop a laboratory model of the future talking-book system.

The NLS Engineering Section lab is also experimenting with a digital audio tape recorder that may be adaptable to production of original masters. Working with the NLS studio, the TARP team aims to digitally master a book in FY95.

Because cost is such an important parameter of any future development, the

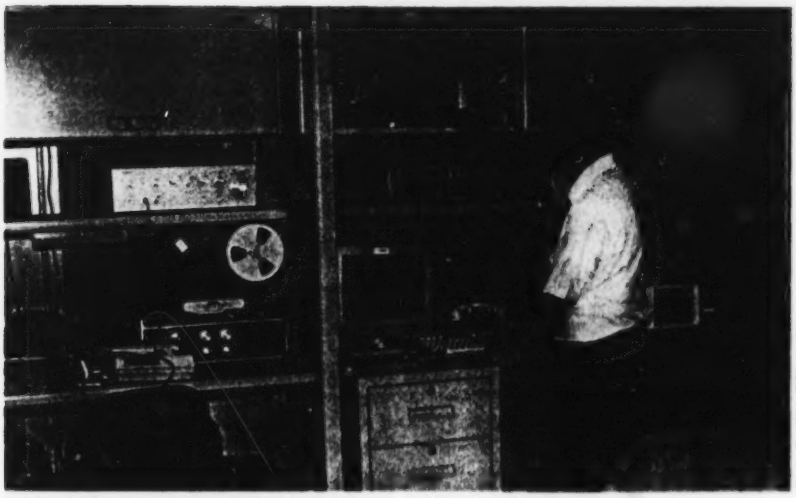

Photo by Yusef El-Amin

Lloyd Rasmussen explores digital coding techniques. Here he reviews excerpts from a digital master stored on the computer. His equipment includes a screen reader with voice output.

TARP team needs a way to compare costs of various alternatives. To make comparisons possible and to help deal with the unknowns, Cookson proposed an "economic model" that will be used to represent the costs of current and projected technology. The model uses known or projected factors, along with estimated levels of confidence in the projections, to develop a measure of cost per circulation for books and magazines. The model will be implemented in computer software so that it can be updated with the evolution of digital audio and so that "what if" scenarios can be investigated.

Photo by Jim Higgins

Raouf Amin and George Stockton work with a commercial digital audio tape (DAT) machine.

System assumptions

So far, discussion and experimentation by the TARP team has seen thinking evolve considerably, and some ideas now seem accepted as working assumptions:

- The new talking-book system must be as affordable as the current system, and it must be so cost-efficient that it will generate enough savings over the present system to at least partially finance the new system.
- Commitment to a new technology must come only after NLS thoroughly studies trends in commercial technology development.
- The new machine will use digital technology, will be modular, will be managed by a microprocessor, and will be independent of any delivery system (such as compact disc [CD], solid-state memory, or electronic transmission). In fact, the use of rotating optical storage (CDs) has been all but ruled out. Currently stationary optical storage seems most promising. Digital technology seems an obvious choice because of its growing use in the music market and because it offers other sought-after features.
- The selected system must be open to features that may not at this time be implemented; therefore, a multimedia—rather than just audio—delivery system will be preferred, and the playback machine's microprocessor must be able to receive enhancements.
- Delivery will be either through mail delivery of a storage medium (such as a memory card) or transmission over an electronic network. The delivery system chosen must be technically superior, it must be in demand by the community, and it must be economically compelling.
- The controls will be manual, but the machine may also be optionally controlled by voice commands, probably communicated through a remote.
- The controls will use a hierarchical system that allows the reader to make choices as simple as "on" and "off" or, if he or she wishes, to choose more complicated playback features such as variable speed and searching.

Preliminary models

Agencies in other countries have also been experimenting with new talking-book ma-

chines. In March 1993, John Griffiths, RNIB audio production manager, demonstrated a laboratory prototype digital machine based on the CD-ROM XA format at a special TARP meeting. Although the TARP team did not feel this product would meet NLS's needs at the time, NLS and RNIB agreed to continue exchanging information, to work toward compatibility, and to avoid duplication of effort.

Following the timeline laid out in 1991, the TARP team has about three years more to experiment before developing a preliminary model for the next-generation talking-book system. The model will be subjected to extensive testing by patrons and librarians and further developed before it is mass produced, probably early in the next century. By that time, a plan must be in place for the transition from cassette and disc playback machines to the projected digital talking-book machine, and for the international exchange of materials.

—Ruth Nieland

Photo by Yusef El-Amin

John Cookson uses ABX listening test equipment to determine the most compact way to store audio material. Test subjects compare CD-quality audio with denser types of coding.

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